CLAIMS

1. A modulator-amplifier configured for use in parametric sound reproduction systems for reproducing audio information in a medium, comprising:

an input configured for receiving at least one input signal including audio information;

at least one reference signal generator configured for generating at least one reference signal;

at least one comparator coupled to the input and the reference signal generator configured for detecting a relationship between a first signal based on the at least one input signal and the at least one reference signal and generating a second signal based thereon;

at least one switching power stage coupled to the at least one comparator and configured to receive the second signal and drive an output signal including at least one sideband and audio information; and

wherein the relationship between the at least one input signal and the timing of state transitions in the switching power stage is non-linear.

2. A modulator-amplifier as set forth in claim 1, wherein the medium comprises air.

3. A modulator-amplifier as set forth in claim 1, wherein the medium comprises water.

4. A modulator-amplifier as set forth in claim 1, wherein the output signal comprises two sidebands.

5. A modulator-amplifier as set forth in claim 1, wherein the output signal comprises two sidebands and satisfies at least one condition of a) the audio information being divided between the two sidebands unevenly and b) the strength of the signal is divided between the two sidebands unevenly.

6. A modulator-amplifier as set forth in claim 1, wherein the modulator-amplifier is configured for either single sideband (SSB) or double sideband (DSB) modulation.

7. A modulator-amplifier as set forth in claim 1, wherein the second signal is one of bi-level, tri-level, 4-level, and 5-level.

8. A modulator-amplifier as set forth in claim 1, wherein the at least one reference signal has a periodic waveform that is one of sinusoidal, triangle and rectiform.

9. A modulator-amplifier as set forth in claim 1, wherein the modulator-amplifier is implemented with analog electronic components.

10. A modulator-amplifier as set forth in claim 1, wherein the modulator-amplifier is implemented with at least one digital electronic component.

11. A modulator-amplifier as set forth in claim 10, wherein the at least one digital electronic component comprises a gate array.

12. A modulator-amplifier as set forth in claim 11, wherein the gate array is field-programmable.

13. A modulator-amplifier as set forth in claim 1, wherein the at least one reference signal generator further comprises a carrier level controller, whereby output power can be varied by varying the amplitude of the at least one reference signal.

14. A modulator-amplifier as set forth in claim 1, wherein output power can be varied by varying amplitude of the output signal.

15. A modulator-amplifier as set forth in claim 14, wherein the output power can be adjusted by adjusting a voltage swing between states in the at least one switching power stage.

16. A modulator-amplifier as set forth in claim 1, wherein output signal amplitude is multiplied by an integer value in the at least one switching power stage.

17. A modulator-amplifier as set forth in claim 1, further comprising a signal processor in communication with the input which generates a level signal based on the level of the at least one input signal, wherein the at least one reference signal is amplitude modulated in accordance with the level signal.

18. A modulator-amplifier as set forth in claim 17, wherein the at least one reference signal generator modulates amplitude of the at least one reference signal based upon the at least one input signal, thereby adjusting power in the output signal.

19. A modulator-amplifier as set forth in claim 1, wherein a switching frequency of the switching power output stage is less than ten times a frequency of the at least one reference signal.

20. A modulator-amplifier as set forth in claim 19, wherein the switching frequency of the switching power output stage is less than 6 times the frequency of the at least one reference signal.

21. A modulator-amplifier as set forth in claim 1, wherein the non-linear relationship is based on an arcsine function.

22. A modulator-amplifier as set forth in claim 1, wherein the non-linear relationship is selected to minimize switching-induced distortion of audio information in the output signal.

23. A modulator-amplifier as set forth in claim 1, wherein the at least one input signal comprises a sinusoidal waveform.

24. A modulator-amplifier as set forth in claim 1, wherein the at least one input signal comprises an in-phase signal and a quadrature signal.

25. A modulator-amplifier as set forth in claim 1, further comprising a protection circuit coupled to the at least one switching power stage configured for resetting or turning off the at least one switching power stage when input power deviates from a pre-selected range of parameter values.

26. A modulator-amplifier as set forth in claim 1, wherein the modulator-amplifier is operable as one of:

a band-pass amplifier;

a part of one of an AM transmitter and SSB transmitter;

a part of a SONAR system;

a part of a diagnostic ultrasound system; and

a frequency translating amplifier.

27. A modulator-amplifier as set forth in claim 1, wherein output signal switching occurs at one of 2, 3, 4, 5 and 6 times a frequency of the at least one reference signal.

28. A modulator-amplifier as set forth in claim 1, wherein the output signal comprises at least one of an upper sideband, a lower sideband, both upper and lower sideband.

29. A modulàtor-amplifier, comprising:

an input configured for receiving at least one input signal including audio information;

at least one reference signal generator configured for generating at least one reference signal;

a switch mode modulator configured to modulate the at least one reference signal, configured so that there is a non-linear relationship between the at least one input signal and state transitions of a switching output waveform; and

wherein the modulator-amplifier is operable for use in a parametric sound reproduction system for reproducing audio information in a medium, the modulator-amplifier generating an output signal that has been shifted in frequency relative to a frequency of the at least one input signal, and includes at least one sideband.

30. A modulator-amplifier as set forth in claim 29, wherein the medium comprises air.

31. A modulator-amplifier as set forth in claim 29, wherein the output comprises two sidebands and satisfies at least one condition of a) the audio information being divided between the two sidebands unevenly and b) the strength of the signal is divided between the two sidebands unevenly.

32. A modulator-amplifier as set forth in claim 29, further configured to perform either SSB or DSB modulation.

33. A modulator-amplifier as set forth in claim 29, wherein the at least one reference signal is single-edge modulated.

34. A modulator-amplifier as set forth in claim 29, wherein output switching comprises one of bi-level, tri-level, 4-level, and 5-level switching.

35. A modulator-amplifier as set forth in claim 29, wherein the at least one reference signal has a periodic waveform that is one of a sinusoidal waveform and a triangle waveform.

36. A modulator-amplifier as set forth in claim 29, wherein the modulator-amplifier is implemented with at least one digital electronic component and the at least one input signal comprises pulse-code modulation.

37. A modulator-amplifier as set forth in claim 31, wherein the at least one digital electronic component comprises a field programmable gate array.

38. A modulator-amplifier as set forth in claim 29, wherein sound pressure level in the medium can be varied by varying the amplitude of the carrier signal.

39. A modulator-amplifier as set forth in claim 29, further comprising a dynamic carrier level controller in communication with the switch mode modulator.

40. A modulator-amplifier as set forth in claim 39, wherein the dynamic carrier level controller modulates amplitude of the at least one reference signal based upon the at least one input signal, whereby power is added to provide an increased sound pressure level in the medium acted on by a parametric reproduction system, and reduced to reduce sound pressure level in the medium.

41. A modulator-amplifier as set forth in claim 29, wherein a relationship between the at least one input signal and timing of state changes in a switching output stage is based on an arcsine function.

42. A modulator-amplifier as set forth in claim 41, wherein the relationship is chosen so as to minimize switching-induced distortion of audio information in the output signal.

43. A modulator-amplifier as set forth in claim 29, wherein the at least input signal comprises an in-phase signal and a quadrature signal.

44. A modulator-amplifier as set forth in claim 29, wherein the at least one reference signal frequency is proportional to a frequency of AC wall-socket power to which the modulator-amplifier is configured to be connected.

45. A modulator-amplifier as set forth in claim 29, further comprising a power supply rejection circuit employing a feed-forward amplitude/pulse-width adjustment technique for stabilizing triangle and sinusoidal reference signals.

46. A modulator-amplifier as set forth in claim 29, wherein the at least one reference signal is modulated to include audio information on one of: a) a lower sideband; b) an upper sideband; and c) both upper and lower sidebands (AM).

47. A modulator-amplifier as set forth in claim 31, wherein the modulator-amplifier is operable for one of frequency modulation, quadrature phase shift keying (QPSK) and quadrature amplitude modulation (QAM).

48. A system for generating an acoustic output reproducing an audio signal in an acoustic parametric array in an acoustic wave-transmitting medium, comprising:

a) a modulator-amplifier which produces a modulated carrier wave output which comprises a carrier waveform at an ultrasonic frequency modulated so as to include a processed audio signal, the modulated carrier wave output is operable for driving a transducer to reproduce the audio signal from the acoustic parametric array;

the modulator-amplifier including an event generator for generating a timing signal based on comparison of the audio signal and a reference signal;

the modulator-amplifier further comprising a switching output stage coupled to the event generator for signaling the switching output stage, wherein timing of switching state transitions in the output stage is related to the audio signal by a non-linear function; and

b) an ultrasonic transducer coupled to the modulator-amplifier which converts the modulated carrier wave output into an ultrasonic waveform for producing an audio wave in a medium, whereby a pre-processed audio source signal is amplified and reproduced from the parametric array in the medium.

49. A system as set forth in claim 48, wherein the non-linear function comprises an arcsine function.

50. A system as set forth in claim 48, wherein the medium comprises air.

51. A system as set forth in claim 48, wherein the reference signal is one of a) a modulated upper sideband; b) a modulated lower sideband; c) a modulated double sideband (AM).

52. A system as set forth in claim 48, wherein the combined modulator/amplifier can perform amplitude modulation or sideband modulation.

53. A system as set forth in claim 48, wherein the reference signal is sinusoidal and the event generator comprises at least one comparator.

54. A system as set forth in claim 48, wherein the combined modulator/amplifier includes a digital signal processor.

55. A system as set forth in claim 54, wherein the input signal is pulse code modulated.

56. A system as set forth in claim 48, wherein the modulator/amplifier comprises a gate array.

57. A system as set forth in claim 56, wherein the gate array is field-programmable.

58. A system as set forth in claim 48, wherein the modulator/amplifier comprises a switching power output stage wherein steady-state levels is at least 2 and less than 8.

59. A system as set forth in claim 48, wherein the at least one reference signal is one of a) modulated single sideband, and b) modulated double sideband.

60. A system as set forth in claim 48, wherein the switching power output stage has a switching frequency that is one of 2, 3, 4, 5 or 6 times the reference signal frequency.

61. A system as set forth in claim 48 which can be adapted to perform one of: a) SSB; b) DSB; c) FM; d) QPSK and e) QAM modulation using the non-linear relationship of the audio signal to timing of state changes in the switching power output stage.

62. A system as set forth in claim 48, further comprising a power supply rejection circuit, coupled to the switching power output stage.

63. A system as set forth in claim 48, further comprising a dynamic carrier level controller coupled to the switching power output stage which modulates the amplitude of the reference signal based on the input signal level.

64. A system as set forth in claim 63, wherein the dynamic carrier level controller modulates the amplitude of the carrier wave based upon an incoming audio signal level, whereby power is I) added to the amplitude to provide increased sound pressure level and ii) reduced to reduce sound pressure level in the audio output in the medium based upon a sensed requirement of the source signal.

65. A system as set forth in claim 48, wherein the switching power output stage of the modamp has a switching frequency of less than ten times the carrier frequency.

66. A system as set forth in claim 48, further comprising a low-pass filter configured to remove artifacts of switching from the output signal.

67. A modulator-amplifier configured for use in parametric sound reproduction systems, comprising:

a reference signal generator for generating a reference signal;

an event detector-signal generator comprising at least one comparator configured for comparing an input signal with the reference signal and generating a timing signal based upon detected events in the input signal;

a switching power output stage configured for modulating the reference signal based upon the timing signal, whereby signal modulation is integrated with power amplification of

the signal to embody a non-linear relationship between the input signal and the timing of state transitions in the modulator-output stage.

68. A modulator-amplifier as set forth in claim 67, wherein said non-linear relationship comprises an arcsine function.

69. A modulator amplifier as set forth in clam 67, wherein the reference signal is one of lower-sideband, upper-sideband or dual-sideband modulated.

70. A modulator-amplifier as set forth in claim 67, wherein the number of steady state levels in said switching power output stage is selected from the group consisting of: 2, 3, 4 or 5.

71. A modulator-amplifier as set forth in claim 70, wherein switching within the switching power output stage occurs at one of 2, 3, or 4 times the frequency of the reference signal.

72. A modulator-amplifier as set forth in claim 67, further comprising a power supply rejection circuit configured to mitigate variations in a supply voltage.

73. A modulator-amplifier, comprising:

a carrier signal generator;

an event detector configured to generate a state change signal based upon detected events in an audio input signal, said event detector comparing the input signal to a reference signal;

a modulator-switching power output stage configured for modulating a carrier for parametric sound reproduction based upon the state change signal, and wherein the timing of switching between steady state levels in said output stage is related to the audio input signal by a non-linear function; and

wherein the switching frequency is selected from the group consisting of 2, 3, and 4 times the carrier frequency.

74. A modulator-amplifier as set forth in claim 73, wherein the number of steady state levels is one of 2, 3, 4, and 5.

75. A modulator-amplifier as set forth in claim 73, wherein the reference signal can be suppressed and the modulator amplifier operated as a band-pass amplifier.

76. A modulator amplifier as set forth in claim 73, configured for use in a SONAR application

77. An modulator/amplifier (ModAmp) comprising:

a carrier reference generator for generating a carrier reference signal;

an event generator configured for comparing an audio input signal to the carrier reference signal, and generating event trigger signals based on said comparing;

an AM modulator configured for receiving the event trigger signals and generating double sideband modulation of the carrier signal;

an SSB modulator configured for receiving the event trigger signals and generating SSB modulation of the carrier signal; and

an output driver configured for receiving AM modulated or SSB modulated carrier signals and outputting a drive signal based thereon suitable for driving an ultrasonic transducer in a parametric sound reproduction system;

wherein event trigger signals are related to the audio input signal by a non-linear function and modulation is switch-mode modulation based on the event trigger signals.

78. The ModAmp according to claim 77, further comprising:

a power supply configured for powering the ModAmp; and

a power supply rejection circuit.

79. The ModAmp according to claim 77, further comprising an audio preprocessor for generating preprocessed audio input to generate in-phase and quadrature audio input signals.

80. The ModAmp according to claim 79, further comprising an audio preprocessor configured to dynamically control the carrier level based upon the preprocessed audio input.

81. The ModAmp according to claim 77, wherein the ModAmp is configured for one of bi-level, tri-level, 4-level, and 5-level steady states in switching modulation/amplification.

82. The ModAmp according to claim 77, configured to perform at least one of SSB and DSB modulation.

83. The ModAmp according to claim 77, wherein the ModAmp is configured for modulation each with reduced third harmonic.

84. The ModAmp according to claim 77, wherein switching occurs at one of 2, 3 or 4 times the carrier frequency.

85. The ModAmp according to claim 77, wherein the ModAmp is configured for bi-level SSB modulation based on staggered drive.

86. A method for frequency shifting and amplifying an audio signal for use in a parametric loudspeaker system, including the steps of,

i) receiving at least one input audio signal,

ii) creating at least one reference signal,

iii) comparing the at least one input audio signal with the at least one reference signal to derive at least one compared product signal,

iv) delivering the at least one compared product signal to a switching power stage wherein at least one operation is performed selected from the following:

a) - performing nonlinear preprocessing with respect to the input audio signal, and,

b) - creating a non-triangle wave as the at least one reference signal; and

v) frequency shifting and amplifying the input audio signal by modulating the reference signal in the switching power stage.

87. A method as set forth in claim 86, wherein there is a non-linear relationship between the audio input signal and the timing of state changes in the switching power stage.

88. A method as set forth in claim 86, wherein the non-linear processing of the audio input signal is based on an arcsine function.

89. A method as set forth in claim 86, wherein the non-triangle wave is a sinusoidal wave.

90. A method as set forth in claim 86, wherein the reference signal is modulated in one of a lower sideband, upper sideband, or both upper and lower sidebands.

91. A method as set forth in claim 86, wherein switching in the switching power stage occurs at one of 2,3,4,5, and 6 times the carrier frequency.

92. A method as set forth in claim 86, wherein the step of creating at least one reference signal comprises providing a power supply rejection circuit and controlling the frequency of the reference signal to within a selected range.

93. A method as set forth in claim 86, further comprising at least one of the steps of:

performing frequency modulation;

performing quadrature phase shift keying; and

performing quadrature amplitude modulation.

94. A method as set forth in claim 86, further comprising the step of

generating multiple compared product signals based on multiple comparisons of input audio signals and reference signals; and

combining the multiple compared product signals to form a compared product signal.

95. A modulator-amplifier as set forth in claim 10, comprising an application specific integrated circuit (ASIC).